1,146,162

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,146,162

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COMPLETE SPECIFICATION

Improvements in and relating to Heat Exchangers

We, AMERICAN RADIATOR AND STANDARD SANITARY CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 40 West 40th Street, New York, New York 10018, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heat exchangers and concerns heat exchange conduits and means for improving the transfer of heat in exchange circuits of great length. The invention may be used in apparatus for heating or refrigeration or in generators for heating hot water, steam or hot air.

A primary object of the invention is to provide means for improving the heat transferability of a heat exchange conduit such as smoke or exhaust fume ducts, without materially impeding the flow of the heated gaseous medium therethrough.

There are already well known in the art, many different forms of turbulators, but those already known either divide the conduit into much smaller passages, or cause the main passage through the conduit to be substantially reduced, thus increasing the possibility of blocking the passage when fluids containing solid materials are passed.

A further object of the invention is to provide an improved heat exchange conduit for use in hot water and steam generators and for heating and refrigeration systems of various types.

A further object of the invention is to provide a heat exchange conduit having a shaped turbulator element for the above-stated purposes which will produce the advantages of a plate element in terms of heat exchange increase without the disadvantages of the plate element, which are known to the art.

According to the present invention, there is provided a heat exchange conduit comprising a tubular heat exchange body for receiving a fluid heat exchange medium, and a turbulator element disposed within and extending throughout the tubular heat exchange body, the turbulator being formed of rod-like material and shaped so as to provide portions of the element extending generally transversely of the flow path of said fluid medium in not more than four planes extending lengthwise of the tubular heat exchange body, the turbulator element engaging the tubular heat exchange body only at points spaced apart along its length, whereby the turbulence of fluid flowing through the tubular heat exchange body is increased without significantly reducing the free passage through the tubular heat exchange body.

The foregoing and further features of the invention may be more readily understood from the following description of some preferred embodiments thereof, by way of example, with reference to the accompanying drawings, in which:—

Figs. 1 and 2 are cross-sectional views taken through exchange conduits having divider walls as commonly known in the prior art;

Fig. 3 is a fragmentary longitudinal section through one embodiment of a heat exchange conduit according to the invention;

Fig. 4 is a transverse vertical section taken on line 4—4 of Fig. 3;

Fig. 5 is a longitudinal section, similar to Fig. 3, showing a modification of the turbulator element;

Fig. 6 is a sectional view similar to Fig. 3 showing a further modification of the element;

Fig. 7 is a transverse section taken on line 7—7 of Fig. 6; and

Figs 8 to 15 are paired cross-sectional views corresponding to Figs. 3 and 4 and 6 and 7, showing additional modifications of the turbulator element.

In the drawings, where for the purpose of illustration are shown preferred embodiments

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of the invention, attention is directed first to Figs. 1 and 2, each showing a metal heat exchange conduit or tube 11 and each having a central divider wall or plate 12 and 12′. The plate 12 in Fig. 1 may be a thin plate and may be flat or corrugated. The plate 12′ is a relatively thick plate. The simple division of the conduit into two parts by the insertion of the very thin plate is known to improve the heat transfer across the conduit walls, for a given rate of fluid flow. The reasons for this are well known to the art and need not be demonstrated here.

The use of a thicker plate, 12′, further increases heat transfer rate, because it has divided the passage into two parts as indicated for the thin plate, but in addition, has reduced the total flow area, with the result that the fluid velocity is increased, for a given flow rate. Such improvements in heat transfer can have only significant values providing that the conditions of fluid flow are already in the turbulent zone, i.e. that the Reynolds number of the flow condition exceeds 3000 to 10000 depending upon the fluid flowing.

As stated, the invention as depicted in Figs. 3 to 15 has for its purpose to reduce inconveniencies of these known prior art arrangements. To facilitate explaining the invention, the invention will be described in connection with the application in question to circuits such as smoke tubes such as used in boilers for heating hot water or steam.

In Fig. 3, for example, the same heat exchange conduit 11 is provided internally with a generally regularly formed serpentine wire element 14 extending throughout its length. The element 14 in Fig. 3 has generally sinusoidal undulations formed by straight intermediate sections or legs 15 and connecting curved terminals 16 between the straight sections which engage the conduit 11 at points spaced apart along its length, the undulations lying in a common plane.

If the diameter of the wire forming this element has the same dimension as the thickness of the plate 12 or 12′, then when viewed from the end of the conduit, this serpentine element will appear as a flat plate similar to 12 or 12′. It has been found by laboratory tests, that, providing the fluid flow conditions are in the turbulent zone, the improvement of heat transfer rate given by a serpentine as shown in Fig. 3, would be substantially similar to that given by flat plate 12 or 12′, shown in Fig. 1 or Fig. 2, if the serpentine wire diameter corresponds to the plate thickness. However, with the serpentine described, at no point along the conduit is the area reduced by more than one single diameter of the wire. In consequence, it becomes evident that the use of the serpentine, whilst permitting the same degree of turbulence, substantially reduces the risk of blockage along the tube.

Fig. 6 shows a modification of the turbulator element at 17 wherein the same is irregularly-shaped longitudinally but all parts thereof lie in the same plane as depicted in Fig. 7.

Figs. 1 and 2 show only the use of a flat plate for dividing the conduit into two parts. It is also well known to the art, however, that a plate constructed to give a "Y" form or the form of a cross, thus dividing the conduit into three or four parts, will also further improve the heat transfer rates because of the additional turbulence created by the smaller passages thus formed.

Figs. 8 and 9 show a modified form 18 of the serpentine turbulator, illustrated in Fig. 3, obtained by bending the straight legs 15 at some point along the length, such that the two parts make an angle of approximately 120°. If two subsequent loops 19 are bent in this fashion, but in opposite direction, the view at the end of the serpentine will be substantially that shown on Fig. 9. Tests have shown that this configuration will improve the heat transfer rate, in approximately the same measures as a "Y" plate, made from flat plate material, having a thickness the same as the diameter of the wire of the serpentine.

Figs. 10 and 11 show a further modification 20 of the serpentine on Fig. 3, wherein each straight legs 15 is bent at some point along the length through an angle of 90°, to the preceding leg 15, such that the view from the end of the conduit will be as shown in Fig. 11, with loops 21 forming substantially a cross. Laboratory tests have shown that the improvement of heat transmission given by this modified form will be substantially similar to that obtained by a cross manufactured from flat plate material having a thickness the same as the diameter of the wire forming the modified serpentine form.

Fig. 5 shows a modified turbulator 14′ formed of a central axial wire 22 having cross wires 23 welded or otherwise fixed thereto at regular intervals. The construction in Fig. 5 differs from the others in that the turbulator is not formed from a single continuous length of wire or material.

Laboratory tests have shown that this modified form will give an improvement in heat transfer rate substantially similar to that obtained by the use of a single flat plate having a thickness the same as the diameter of the vertical wires or rods 23, shown in Fig. 5.

In the embodiments of the invention described with reference to Figs. 3 and 4 or Figs. 6 and 7 or Figs. 8 and 9, or Figs. 10 and 11, the turbulator element is formed so that its longitudinal undulations project from the centre, outwardly toward the interior surface of the tubular body and lie in one or more radial planes.

In Figs. 12 and 13 and Figs. 14 and 15 the turbulator elements 24 and 25 respectively are generally spirally formed along the axis of the conduit 11. Thus these figures of the draw-

ings show additional shapes or modifications of turbulators 24 and 25 which are among many possibilities conceivable under the invention, such that, by bending one straight part in relation to the previous part, the end view of the turbulator will give a triangle as shown in Fig. 13, or a square as shown in Fig. 15.

A turbulator constructed from rod or wire and wound in a spiral form so as to lie substantially in continuous contact with the conduit wall is well known to the art.

This form of turbulator and the flat plate forms of turbulator, have the inconvenience that a significant amount of the heating surface of the conduit wall is covered by the spiral or by the edges of the flat plates. It is a further advantage of the turbulators according to this present invention, that the conduit walls are only touched at points, with the results that only a very small part of heating surface is impeded.

Heat exchange devices constructed in accordance with the invention are very economical to construct and assemble and are highly efficient. The construction results in a great lessening of fouling of passages by smoke charged with solid particles as compared with arrangements utilizing continuous divider walls. Additionally, the elongated wire or rod type turbulator allows the major portion of the conduit cross-sectional opening to remain unblocked for the easy passage of smoke or gas.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the scope of the invention claimed.

WHAT WE CLAIM IS:—

1. A heat exchange conduit comprising a tubular heat exchange body for receiving a fluid heat exchange medium, and a turbulator element disposed within and extending throughout the tubular heat exchange body, the turbulator being formed of rod-like material and shaped so as to provide portions of the element extending generally transversely of the flow path of said fluid medium in not more than four planes extending lengthwise of the tubular heat exchange body, the turbulator element engaging the tubular heat exchange body only at points spaced apart about its length, whereby the turbulence of fluid flowing through the tubular heat exchange body is increased without significantly reducing the free passage through the tubular heat exchange body.

2. A device as claimed in Claim 1 wherein the turbulator element is of longitudinally undulated form, being composed of a single, continuous length of rod-like material.

3. A device as claimed in Claim 2, wherein the element has its undulations lying substantially in a common plane.

4. A device as claimed in Claim 2 wherein said element is formed so that its longitudinal undulations project from the centre, outwardly toward the interior surface of the tubular body and lie in multiple planes.

5. A device as claimed in Claim 2, 3 or 4 wherein said undulations are regularly and generally sinusoidal.

6. A device as claimed in Claim 2, 3 or 4 wherein said undulations are irregular and serpentine.

7. A device as claimed in Claim 1 wherein the turbulator element is composed of a single, continuous length of rod-like material, generally spirally formed along the axis of the tubular heat exchange body.

8. A heat exchange conduit substantially as hereinbefore described with reference to Figs. 3 and 4 of the accompanying drawings.

9. A heat exchange conduit substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings.

10. A heat exchange conduit substantially as hereinbefore described with reference to Figs. 6 and 7 of the accompanying drawings.

11. A heat exchange conduit substantially as hereinbefore described with reference to Figs. 8 and 9 of the accompanying drawings.

12. A heat exchange conduit substantially as hereinbefore described with reference to Figs. 10 and 11 of the accompanying drawings.

13. A heat exchange conduit substantially as hereinbefore described with reference to Figs. 12 and 13 of the accompanying drawings.

14. A heat exchange conduit substantially as hereinbefore described with reference to Figs. 14 and 15 of the accompanying drawings.

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Fig. 1.

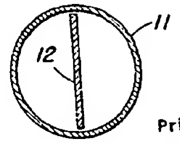
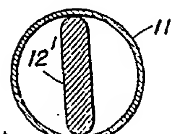


Fig. 2.



Prior Art

Fig. 5.

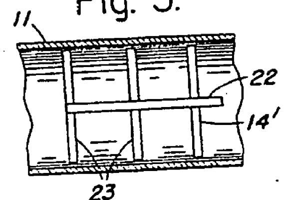
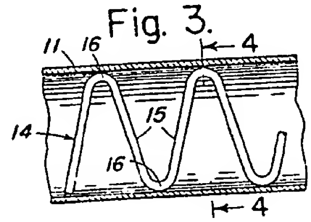


Fig. 3.



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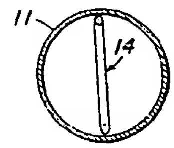

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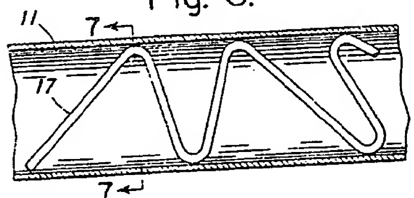


Fig. 7.

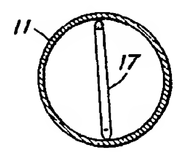


Fig. 8.

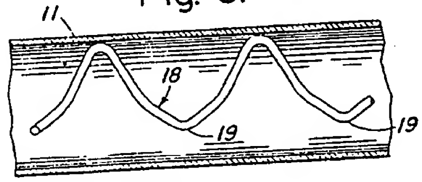
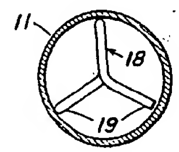


Fig. 9.



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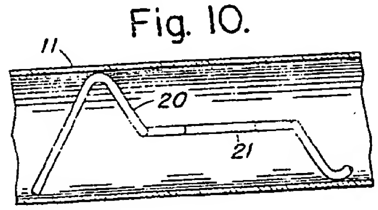
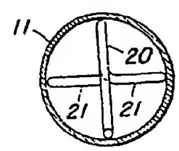


Fig. 11.



1146162 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

Fig. 12.

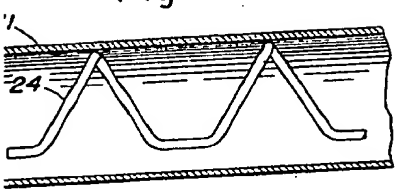


Fig. 13.

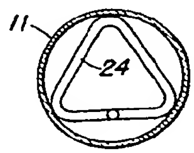


Fig. 14.

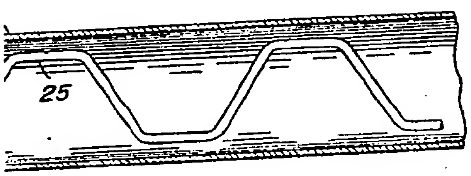
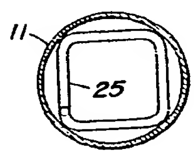


Fig. 15.



1146162 COMPLETE SPECIFICATION

2 SHEETS This drawing is a reproduction of the Original on a reduced scale Sheets 1 & 2

Fig. 1.

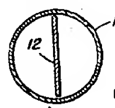
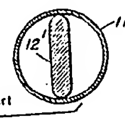


Fig. 2.



Prior Art

Fig. 3.

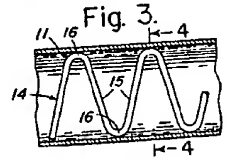
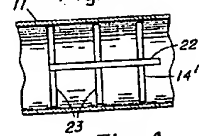


Fig. 5.



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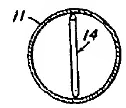

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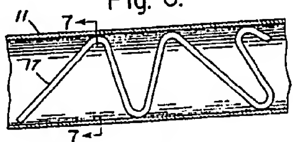

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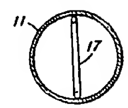

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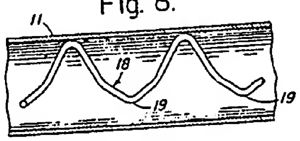


Fig. 9.

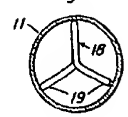
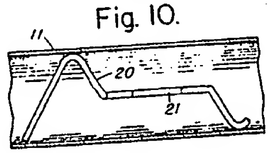


Fig. 10.



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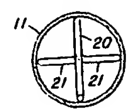

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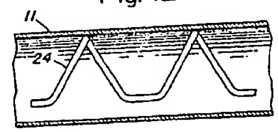

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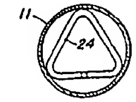

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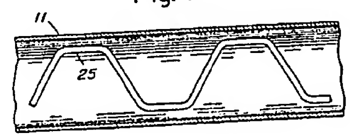

Fig. 15.